THE HISTORY AND CONSTRUCTION OF THE HANOVER STREET BRIDGE, IN BALTIMORE, MARYLAND.

THESIS PREPARED BY

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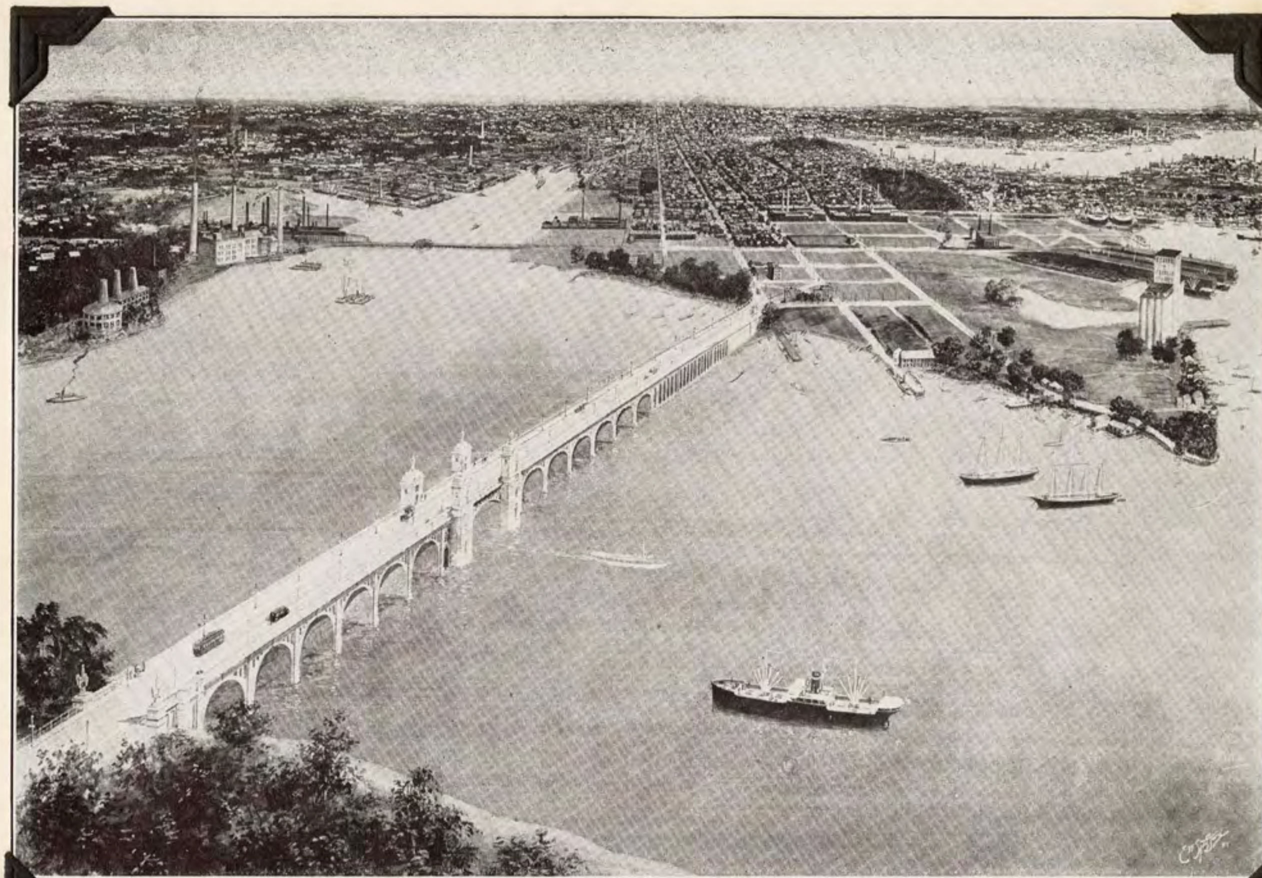

BIRD'S-EYE VIEW SHOWING SECTION OF THE HANOVER STREET BRIDGE ACROSS MIDDLE BRANCH.

The point in the right middle ground is Ferry Bar.

SUMMARY

Prior to 1856, communication from Ferry Bar, Baltimore City, to Anne Arundel County was by ferries running to a number of points. In 1856, Richard O. Crisp and Richard Cromwell were given the right to build a toll bridge from Ferry Bar across to Brooklyn in Anne Arundel County. This bridge was operated until 1880, when the city of Baltimore and Anne Arundel County bought it. It was reconstructed of timber in 1891 and remained in use until 1916, when the present bridge was constructed.

The Hanover Street Bridge is a true cantilever bridge encased in reinforced concrete to give the appearance of a true elliptical arch. The cantilever design was adopted on account of the soft mud and treacherous bottom and economical construction. The piers are of concrete, with just enough reinforcing to bind and confine the mass. The superstructure consists of a retaining wall resting on piles, a long arcade and twelve cantilever spans with a Rall type bascule bridge for the channel. The retaining wall extends for 250 ft. 9 in. The arcade is 450 ft. 10 in.long. The center to center distance between the piers for the cantilevers is 103 ft. 0 in., and the bascule is 286 ft. 4 in. long. The spans of the superstructure consist of ten arch ribs composed of structural steel. The total length of the

bridge between abutments is 2290 ft. 2 in. There are 50 feet of clear roadway and two 8 ft. sidewalks. Included in the bridge project was the cutting thru the point of land between the middle branch and the main branch of the Patapsco River, and filling and building two bridges across the main branch. These bridges are of the reinforced concrete girder type 500 ft. and 100 ft. long. All conditions as to roadway, sidewalks, conduits, loading, etc. are the same as the main bridge across the middle branch.

At the present time, the entire project while not unsafe for use, is in poor condition structurally. The arcade and the fill at the north, or Baltimore end of the main bridge, are settling. The concrete work is in poor shape on the big bridge, having crumbled in numerous places. The fill at the main branch has settled and continues to settle; and the north abutment of the 500 ft. bridge must be replaced. The entire job, in the opinion of various people, was poorly carried thru, with the result that there has been a continual patching process required to keep the project in passable condition.

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" " " " " Harbor Engineer of Baltimore, Md.

Partial Specifications in possession of the State Roads Commission of Maryland.

The writer wishes to express his gratitude to the various engineers of the City of Baltimore and the State of Maryland who were very kind in placing at his disposal the various plans and specifications which were available. However, due to the age of the structure and the little use of information on this bridge, the plans and specifications were very incomplete.

HISTORY

The Patapsco River, at Ferry Bar, separated the southern part of Baltimore from what used to be a populous and prosperous farming district around Brooklyn in Anne Arundel County. True, there was a bridge across the river at Pumphrey, Anne Arundel County, but this route into Baltimore meant a detour of several miles. Rather than take this long trip, most of the people of the Brooklyn section resorted to ferries, of which there were several, running from Ferry Bar to various points on the county shore. Possibly the most picturesque of the old ferrymen was Jack Flood known to the older generation of Baltimore for his Beer Garden on Ferry Bar.

Richard Cromwell was a wealthy farmer, of the Brooklyn district, who owned a 500 acre farm. It was the difficulty and expense of getting the products of his farm to market that led him with Richard O. Crisp to petition the Maryland Legislature for the right to build a toll bridge from Ferry Bar across to Brooklyn. By authority granted under Acts of 1856, Chapter 215, Laws of Maryland, the two men were granted their request. The bridge which was constructed was the parent of the later Light Street Bridge and the present Hanover Street span. The old bridge,

being one mile long, was nicknamed "Long Bridge", and this name stuck to the Light Street structure until its demolition in (1916). The bridge operated as a toll bridge on a well paying basis until 1880, when it was purchased by the Mayor and City Council of Baltimore and the County Commissioners of Anne Arundel County at a cost of $3500. After this time the bridge was made free.

In 1891, the bridge was reconstructed of timber, with a turn draw over the channel at a cost of about $156,000. The reconstructed bridge was officially known as the Light Street Bridge because of the fact that its Baltimore end was at the foot of Light Street. This structure, with very extensive repairs, remained in use until the Hanover Street Bridge was opened to traffic in 1916.

The importance of the bridge as a link between Baltimore and Annapolis and Southern Maryland increased as time went on. The traffic over it, to these points, increased so greatly that a larger, more modern, and more permanent bridge became imperative. In 1913 the City of Baltimore voted on a bond issue of $2,000,000 to replace the bridge; but the loan was defeated by popular vote. In 1914 the Maryland Legislature appropriated $1,600,000 from the State road loan, under Chapter 267, to be used in Baltimore

City. The State Roads Commission was to erect a new bridge along the lines of the old Light Street Bridge or from the foot of Charles or Hanover Streets, to a point of land in Baltimore County, thence by a street across the point of land in Baltimore County to the Patapsco River, and across the Patapsco River by a fill and bridge to First Street, Brooklyn, Anne Arundel County. The point of land in Baltimore County, as well as Brooklyn, is now a part of Baltimore City. If there was any unexpended balance remaining, the same was to be spent on paving streets in Baltimore City. In compliance with this Act the State Roads Commission made an investigation into the most logical location for the bridge. After exhaustive studies and a number of conferences with the United States Engineer's office, as well as with those interested, it was decided to construct the bridge from the foot of Hanover Street. This was done so as to interfere as little as possible with the commerce of the harbor and throw below the bridge a very much larger area which could be used for harbor purposes. At the same time, this gave a great deal more pier frontage below the bridge so that vessels plying in this locality would not have to pass thru the draw.

CONSTRUCTION OF PRESENT BRIDGE

The main bridge over the Middle Branch is 2290 ft. 2 in. long, from its Baltimore, or northern extremity, to its southern abutment. From the northern end a reinforced concrete retaining wall resting on piles extends on a fill 250 ft. 9 in. into the river. A reinforced concrete arcade extends from the end of the retaining wall 450 ft. 10 in. to pier number 1. There are twelve cantilever spans for which the piers are placed 103 ft. 0 in. center to center, and a Rall type bascule bridge 286 ft. 4 in. in length over the channel. The roadway is 50 ft. in the clear, and there are two sidewalks which are 8 ft. wide. The bridge is designed for a dead load of 1530 pounds per square foot of surface, and two street car tracks weighing 250 pounds per lineal foot. The live load is for two 50 ton electric cars, one on each track with two four wheel trucks; on the roadway two 24 ton trucks; and on the sidewalks 100 pounds per square foot. The live load stresses were increased by 15 per cent for impact.

A very close investigation was made of the bottom for the construction of the substructure of the bridge. The depth of the water was from four to twenty-eight feet deep in the channel. The sub soil consisted of

50 ft. of soft mud, then a strata of gravel and sand, then clay, then a layer of gravel to solid bottom which was approximately 100 ft. below the surface of the water.

The substructure for the retaining wall and arcade consists of Georgia long leaf pine piles driven from 75 ft. to 100 ft. below the surface of the water, and filled around with gravel and sand up to five feet above the water. The refusal of these piles was 1/2 in. movement per blow for five blows of a 3000 pound hammer, with a 15 ft. drop. The concrete in the wall was 1 - 2-1/2-5 mix below the coping; and 1 - 2-4 mix in the coping and above. The reinforcement consisted of 3/4 in. open hearth steel reinforcing rods placed 3 diameters apart. The arcade consists of 95 reinforced concrete columns resting on piles like the retaining wall. There are 19 transverse rows of these columns, 5 across.

The piers are 15 in number. Four of these are extra heavy because of their connection with the bascule. Another, the first pier beyond the arcade is heavier than the remaining piers. The piles, for the footings of all the piers, were driven any where from 75 ft. to 100 ft. below the surface of the water. Owing to the great depth of soft mud, the foundations were difficult and extraordinary care had to be taken with the building and bracing

of the cofferdams. The mud was pumped from the cofferdams down to from 30 ft. to 40 ft. below the surface of the water. The piles were then filled around with unwashed gravel to a depth of about 5 ft. The concrete was poured on the gravel as a base. The ordinary piers, of which there are ten, were set on 250 piles each. The footings at the base measure 26 ft. 0 in. x 60 ft. 6 in. and the total concrete in the ten piers is 2355 cu. yds. of 1 - 2-4 mix and 6610 cu. yds. of 1 - 2-1/2-5 mix. The five larger piers are set each on 319 piles. The footings at the base measure 30 ft. 4 in. x 80 ft. 6 in. The concrete in the piers near the bascule totals 1752 cu. yds. of 1 - 2-4 mix and 4524 cu. yds. of 1 - 2-1/2-5 mix, while pier No. 1 at the end of the arcade contains 353 cu. yds. of 1 - 2-4 mix and 953 cu. yds. of 1 - 2-1/2-5 mix. Anchor bolts for the steel work of the superstructure are set in each of the piers. All of the piers are reinforced horizontally by a network of 3/4 in. reinforcing rods spaced 6 in. apart just above the bed of the footing. The vertical reinforcing consists of just sufficient reinforcement to bind and confine the mass of the pier. The stability factor of the piers is 2. The south abutment of the bridge is built on a base of 130 reinforced concrete piles. The concrete used thruout the piers is granolithic. The working stresses

allowed in the concrete work are as follows: Compression stresses; concrete under direct compression allowed 450 pounds per square foot; bending stress on concrete allowed on unconfined surface of concrete is 650 pounds per square foot. There is no allowable tension stress in concrete. The tension stress for steel is 16,000 pounds per square foot. The shear stress for concrete is 120 pounds per square foot, while the shear stress for the reinforcing rods is 12,000 pounds per square foot.

The spans of the superstructure consist of 10 arched ribs composed of structural steel; The steel being made strong enough to carry the dead load of the concrete and the forms. The steel arch ribs were made at Sparrows Point, floated to the site of the bridge on lighters, and lifted into place by heavy derricks. Nuts to the anchor bolts were screwed down, the forms placed and the concreting begun. This made the erection extremely simple and no underbracing whatever was necessary. The spans are true cantilever and all stresses and strains were computed for such. The concrete covering gives the bridge the appearance of a true elliptical arch.

The sheet asphalt roadway of the bridge is carried on the reinforced concrete slab of the bridge. The sidewalks are of reinforced slab concrete with a granolithic

finish. The guard rail of the bridge is of monolithic reinforced concrete about 10 in. thick. These rails are a continuation of the sides of bridge, being tied to the lower structure by the reinforcing rods. The expansion joints, which were placed in the concrete work of the superstructure when the bridge was built, proved inadequate and up until 1931, when extensive repairs were made, there was a continual patching going on at these joints.

The draw span has a clearance of 38 ft. 6 in. above mean low water and a width in the clear when open of 150 ft. The length between breaks in the roadway at each end is approximately 195 ft. 8 in. In each leaf there are two principal structural steel cantilevers one 25 ft. on each side of the center line of the bridge. Their overall length is 110 ft. 8 in. The 21 in. horizontal axles divide these into long and short arms of 80 ft. 8 in. and 30 ft. The cantilevers are braced together with the floor beams and top and bottom laterals, and carry the street car tracks and roadway. The paving of the roadway on the draw consists of creosoted wooden blocks resting on the reinforced concrete slab of the bridge deck. The 8 ft. sidewalks are cantilevered outside the girders on structural steel brackets which are secured to the vertical members of the girders. The sidewalks on the draw consist of 1-1/2 in. planking placed transversely on the stringers and the railing on the draw is of steel.

The trunnions are of hollow forged steel about 8 ft. long, 21 in. in diameter at the bearing in the roller and 12 in. in diameter on the inner end bearing. The short arm on each leaf contains a steel plate box, holding the concrete and stone counterweights. When the draw is closed, there is a 4 in. clearance between the ends of the leaves and the entire load is taken by the cantilever action of the short arms engaging the horizontal transverse anchorage reaction girder set in the heavy piers adjacent to the main bascule piers. There is a shear lock at the center of the span consisting of two 3/4 in. steel plates 6 in. wide and having a longitudinal movement of 15 in., which tends to distribute the shearing force over both leaves. This lock is located in the north leaf, the plates engaging sockets in the end of the south leaf. The locking device is controlled thru a system of gears and levers either by motor or by hand from the operating house at the northeast corner of the draw.

The operation of the draw is by the Rall bascule method, the patent for which is held by the Strobel Steel Construction Co. of Chicago, Ill. It consists of segmental racks bolted on to the short arm of the cantilever girders and travelling on a pivoted operating arm. At the same time, the trunnions which are mounted on rollers 80 in. in diameter and with 20 in. faces move thru a horizontal

distance of 12 ft., while the ends of the leaves rise. The racks on each leaf are driven by two General Electric 30 H.P. A.C. motors which are fully enclosed and have waterproof insulation. The four motors for the draw are all controlled from the northeast operating house, the power for the motors on the south leaf being carried by a submarine cable across the channel. The motors and operating machinery are set under the ends of the span, and they are controlled by means of brake bands, controllers, and resistances. The gears are all cast steel, their teeth, rims, etc. running true. Their attachment to the shafts are a light drive fit keyed. Mating spur gear wheels are placed so that the molding draft of their teeth is reversed. The teeth are all trimmed to template so that the bearing marks extend over half their length. The gear teeth are of the involute curve type having an angle of obliquity of 15°. The depth of the teeth is 65 times their circular pitch. The journal blocks are of cast steel lined with babbit. Shafting over 4-1/2 in. diameter was forged or rolled and turned while that of 4-1/2 in. diameter and under was cold rolled.

All forgings are annealed and carefully inspected. The trunnion bearings are provided with compression grease cups, using a fine grade of graphite grease. The trunnion shafts are provided with 1/2 in. slots to distribute the

grease. There are three grease cups to each bearing. There is also provided auxilliary hand gear operated by a capstan for lifting the leaves of the bascule. These emergency devices are located one in the roadway at the bridge end of each leaf.

The bascule piers are protected by buffers on each side of the channel. These buffers consist of rows of timber piles extending up and down the river for 100 ft. on either side of the bridge. These piles are placed 10 ft. from the piers. Three horizontal girts are bolted and spiked on the piles and vertical planking extending well below low water and about 15 ft. above mean low water was placed on the girts. At the ends of the buffers, clusters of piles, bound with wire cable, were placed. At this point, it will be interesting to note that it was necessary to dredge a new channel as one of the piers of the draw span stood directly in the old channel. 175,000 cu. yds. of earth had to be removed at a cost of $20,000 so as to arrange the new channel to fit the draw opening.

There are four houses at the draw but only one, that at the east end of the north pier, is used for an operating house. The southeast and the northwest houses were, until a few years ago, used as comfort stations. However, the failure of the construction engineers to locate accurately the water mains on the bridge necessitated the

closing of these comfort stations due to the impossibility of fixing a burst water main. The southwest house is used merely as a storeroom and waiting station. The houses are of reinforced monolithic concrete extending down to the draw piers and the heavy piers adjacent. (Note - The contract drawings called for these houses to be placed on a footing of piles. However, Mr. Kipp, the Harbor Engineer of Baltimore City, states that these houses are merely spanned across adjacent piers, there being no footing below them). The houses are about 29 ft. 6 in. long, 12 ft. wide, and 34 ft. 2 in. high. They are surmounted with ornamental copper lights. There are two stories above the bridge and a companionway leads to the piers underneath.

The operating house contains all the controls and automatic devices used in connection with the draw. Motor operated safety gates of the type used at railway grade crossings close the roadway on each side of the draw when the draw is open. These gates are controlled from the operating house. The house contains, besides the switchboard, brakes and controllers for various motors, many electrical devices which promote the safer operation of the draw. There is a system of lights showing the position of each leaf of the draw in various stages; open, nearly open, free, nearly closed, and closed. By means of this device, the operator may tell exactly where each leaf is without

leaving his post. There is a like system which indicates whether the shear lock at the center of the span is locked or unlocked. There are navigation lights showing up and down the river which show red while the draw is closed but automatically turn to green when the draw reaches its full height.

Included in the Hanover Street Bridge project was the cutting thru the point of land in Baltimore County and carrying the road across the main branch of the Patapsco River by means of a fill, a 500 ft. bridge and a 100 ft. bridge to First Street, Brooklyn. The entire length of this part of the project is about 5800 ft. Approximately 200,000 cu. yds. of earth were removed from the cut and placed in the fill. The cut at the deepest point was 45 ft. The section of fill from the Baltimore County side of the 500 ft. bridge over the channel of the Patapsco River was placed over a very soft bottom and there is still trouble with this portion of the roadway settling. The two bridges are of the reinforced concrete girder type. They are of the same width as the main bridge and are designed for the same loads.

The design of the bridge was worked out under the supervision of Mr. J.E. Greiner, Consulting Engineer, Baltimore, Md. The contract for the sub and superstructure of the bridge across the Middle Branch was awarded to

H.P. Converse and Co. of Boston, Mass. The contract for the construction of the lift spans over the main channel was awarded to the Strobel Steel Construction Co. of Chicago, Ill. The contract for the small bridges was awarded to the McLean Contracting Co. of Baltimore, Md. The total cost of the main structure including paving, lighting, drawbridge, etc. was approximately $900,000. The cost of the cut and fill was approximately $115,000. The cost of the small bridges was approximately $130,000. The total cost of the entire project was approximately $1,200,000.

There have been extensive repairs made on the project since 1916. In 1917 and 1918 several of the footings under the arcade of the main bridge had to be replaced. The mud had caused the old footings to shift and caused some dangerous conditions in the bridge. From 1925 on, each year there was work done on the concrete work at the expansion joints which were faulty. In 1931 the faulty expansion joints were replaced and since that time there has been very little trouble of this sort. At the fill in the main branch of the Patapsco River there has been much trouble with settlement due to the soft bottom. In 1932 the roadway was torn up half at a time, so as not to interfere with traffic, and piles were driven to carry the roadway. However, the roadway continues to settle and there has been no satisfactory remedy worked out to date.

The north abutment of the 500 ft. bridge at the end of this fill is, at the present time, in such a condition as to require replacement in the near future.

CONCLUSION

The Hanover Street Bridge is, in the opinion of the engineers in charge of its maintenance, an extremely poor piece of work. It was the first large bridge construction project that the State Roads Commission ever attempted, consequently, the inspectors on the job had little or no experience in the work they were expected to do. This fact is evidenced by the absence of the footings for the operating houses and the inadequate expansion joints, as well as the more serious impairment in the form of the shifting of the footings under the arcade. However, in the past few years, the repairs which have been made, and are being contemplated will keep the bridge in passable condition for several years.

The draw is not very much used at present. Most of the marine traffic under the bridge consists of tugs hauling barges and old schooners carrying lumber and bricks into the upper reaches of the Middle Branch.

The bridge, although itself none too good structurally, was a stepping stone to better bridges for the

State Roads Commission. At the present time, it is carrying its volume of traffic to Annapolis, Southern Maryland, and the lately opened shore resorts along the Chesapeake and its rivers. It is performing the task for which it was built.

Map showing location of old and new bridges.

View looking south across the Patapsco River from Ferry Bar. Piles from the old bridge may be seen just offshore.

View of Middle Branch bridge looking north from

Broening Park.

View of bridge looking west from Ferry Bar.

View under one of the arches showing the ten girders comprising each span.

View of the west side of the south abutment.

View under the arcade at the north end of the bridge.

View showing the under side of the south leaf of the Bascule, taken while the draw was open.

Two views of the steel work of the Bascule.

One of the four houses next to the Bascule.

Plate on the Bascule.